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AUTHOR Tsui, Hing Fung; And Others
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ABSTRACT

The research study investigated the memory and metamemory abilities of four severely to profoundly deaf students with bilateral sensory-neural loss, between the ages of 9 and 20 years. Metamemory was investigated with four modified subtests identified as "story list," "study plan," "retrieval event," and "opposites-arbitrary." Encoding was investigated with a spatial position versus temporal position test. Retrieval was investigated with free-recall of a clusterable word list and paired associate recall of prototypically associated items and non-protypically associated items. Results indicated that the working memory capacity of deaf subjects was depressed. Inefficiency in encoding was observed. Results suggested that the ability to encode both spatial and temporal information is related to some degree of reflective thinking in metamemory. Rehearsal mechanism was associated with temporal position recall and non-prototypical condition. Clustering strategy in free-recall was correlated with semantic knowledge, whereas performance on the prototypical condition in paired-associate learning was highly automatic. Semantic knowledge was correlated with metamemory and free-recall performance. Age trend was observed in metamemory in general, with different patterns on the subtests. (Author/DB)

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MEMORY AND METAMEMORY IN DEAF STUDENTS[1]

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Hing Fung Tsui and Michael Rodda
University of Alberta, Edmonton
and
Carl Grove

Abstract

The research study investigated the memory and metamemory abilities of 4 severely to profoundly deaf students with bilateral sensory-neural loss, between the ages of 9 years and 20.42 years. Based on recent cognitive and metacognitive theories, the research purpose was to obtain a descriptive profile of the interactions among different variables. Metamemory was investigated with four modified subtests from Kreutzer, Leonard, and Flavell's (1975) interview, which are story list, study plan, retrieval event, and opposites-arbitrary. Encoding was investigated with a spatial position versus temporal position test. Retrieval was investigated with free-recall of a clusterable word list and paired-associate recall of prototypically associated items and non-prototypically associated items. The other measurements used were forward digit span for determining capacity, pre-test word review for knowledge assessment, and an interpolated task of color sequence matching. Testing was conducted in manual communication with a sign language interpreter. Results indicated that the working memory capacity of deaf subjects was depressed. Inefficiency in encoding was observed. Overall, the results did not suggest a spatial bias in encoding, although different patterns were observed when the sample was broken down into three age groups. It was suggested that the ability to encode both spatial and temporal information is related to some degree of reflective thinking in metamemory. Rehearsal mechanism was associated with temporal position recall and paired-associate non-prototypic condition. Clustering strategy in free-recall was correlated with semantic knowledge, whereas performance on prototypic condition in paired-associate learning was highly automatic. Semantic knowledge was correlated with metamemory and free-recall performance. Age trend was observed in metamemory in general, with different patterns on the subtests. The issue of knowledge structure development seemed to be pertinent to the memory development of the deaf.

General Background

Memory models in Psychology have changed from the earliest associationist models to the more recent models to the more recent models of metamemory (e.g., Flavell & Wellman,

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1977; Brown, 1978). Among the many models, there are some which describe information-processing in general, and some which are more specific. Conceptualizations from the currently predominant models often influence the way research questions are constructed. Memory research with the deaf is no exception to this kind of influence.

Most memory studies of deaf people have dealt with only limited aspects of memory -- those assumed to be affected by hearing loss or the lack of a verbal language. However, Wolk (1985) has recently criticized such studies as being unable to distinguish between "representational" and "executive" processes.

The representational process or encoding by the deaf has often been related to the deficiency of audition. It was hypothesized that as auditory input is temporal-sequential in nature, the deficiency in the auditory modality would affect sequential information processing (e.g., O'Connor & Hermelin, 1972, 1973).

Another issue of representation has been the use of the imaginal code by the deaf. The use of such a code was inferred from the visual mode of information processing presumably used by the deaf. The model of dual-coding of Paivio (1971) has also been invoked in studies of the memory of the deaf (e.g., Craig, 1973; Bonvillian, 1983). However, the studies testing the issues of spatial versus temporal code and imaginal encoding have looked exclusively at the memory performance of the deaf in a passive stance. Other studies which explored the effect of sign formational properties on recall (e.g., Bellugi, Klima and Siple, 1975; Liben, Newell, and Posnansky, 1978) or whether the syntax of sign language produced similar facilitation to verbal languages (e.g., Tweney and Heiman, 1977), have also been limited in scope in that these studies were still concerned with the issue of encoding, and the focus was still on the code used but not on the person using the code.

What has been lacking is the investigation of those deliberate retrieval strategies used by more successful deaf learners in learning material, that are not congruent with their naturally occurring processing mode. This issue related to the memory of the deaf students, is important because an orthography based on a verbal language is used in schools, and deaf students are often reported to be behind their hearing peers in language skills.

The Research Problem

Recent research on memory development has offered many insights which could shape the direction of deaf memory research. The research reported in this paper does not rely on one single paradigm of memory research. It has perspectives based on strategies, metacognition, and interpretation of the knowledge base, as well as a socio-genetic perspective. According to new conceptions of memory development, the difference between children's memory and that of adults lies not in the capacity but in the processes. Qualitative and quantitative differences have been attributed to strategies, metamemory, and content knowledge (Chi, 1985).

Strategy development has been postulated as the basic source of cognitive development (Flavell, 1971; Flavell and Wellman, 1977), whereas the metamemory explanation of children's failure to use strategies is their lack of conscious control. In Brown's (1978) view, knowledge of one's cognition or conscious executive control of routines is the essence of intelligent activity. The focus on a knowledge explanation has been advocated by Chi and Reese (1983) and Trabasso (1983). The representation of the conditions for application of a strategic rule can be regarded as the declarative aspect of knowledge. In this light, the understanding of domain-specific knowledge is the first step to understanding memory development.

Although the three possible explanations of memory development seem to be separate alternatives, they are facets of the same cognitive and metacognitive umbrella. However, the

focus on domain-specific knowledge and domain-specific strategies seems to be a more profitable direction for research with the deaf. First, the study of general strategies such as rehearsal by means of manual signing or the lack of it, was not thought to be conducive to the understanding of strategy change. A more worthwhile issue is the use of strategy in increasing task complexity within a knowledge area; in the research context, it would mean looking into the task conditions or levels of task difficulty. Word-understanding has often been taken for granted, but it is a specific domain which is particularly problematic for deaf children, since most deaf school leavers' reading vocabulary seldom progresses beyond that of a nine-year-old (Conrad, 1979), and a plateau of grade three or four reading level is attained by 13- and 14-year-old deaf students (Quigley & Kretschmer, 1982). Although words have been used in memory experiments with the deaf, they have not been employed with a conceptualization that affords them the status of a specific domain under study.

Another adopted view of memory development in the present study is the socio-genetic view of Soviet psychologists. The main exemplifier of this view is Vygotsky (1962, 1978). According to Vygotsky (1978), mental strategies for remembering are reconstructed from social interactions. This focus is called a shift from the "interpsychological" plane of functioning to the "intrapsychological" plane, and the developmental trend is from involuntary to voluntary memory behavior.

The Soviet view provides a useful perspective for studying a special population and also underscores the conceptualization and methodology of metamemory investigations. From the stance of socio-genesis, the deaf population can be viewed as a group which has unergone compromised social experience. Rather than from a deficiency perspective, the research perspective is more akin to that of cross-cultural variation. Cross-cultural research has shown

that variation of memory performance of non-western groups can be a function of the degree of schooling, mobilization of different cognitive processes, or dependence on different contextual cues for memorization (Rogoff and Mistry, 1985). The deaf could be likewise regarded as a special cultural group which does not totally share the same experiences as hearing individuals.

The present study attempted to investigate a spectrum of short-term and long-term memory abilities and metamemory abilities of deaf students. Issues covered pertained to the more familiar question of memory representation in addition to retrieval. Instead of studying memory representation as the only aspect of research interest, memory representation was examined in relation to other memory abilities. Performance and strategy use were studied in relation to long-term semantic memory, short-term capacity, task conditions, metamemory, and age. The concern was whether there was a developmental difference in terms of patterns from what is documented in the literature, taking the deaf sample as a whole, and whether within the age range of the sample, developmental variations occurred. Although the tasks used in the study were not entirely unprecedented, the rationale behind the usage was condensed from recent development of memory research. As memory skills are essentially learning skills, hopefully the end result and the perspectives adopted in this research will facilitate improvement in the learning strategies of deaf children and adolescents.

Method

Sample

Twenty-four subjects were used in the study, 12 male and 12 female deaf students, attending either one of two schools for the deaf, between the ages of 9 and 20.42 years. The mean age of the sample was 15.36 years. All subjects had bilateral sensory-neural hearing loss,

ranging from severe to profound in the better ear. Fourteen had deafness diagnosed at birth, seven had their hearing loss diagnosed in early and late infancy, and three had unknown age of onset and etiologies.

The subjects were screened either according to the reading vocabulary test results of the Canadian Achievement Tests in one school or according to results on language arts in the school report in the other. Grade three reading level was used as the criterion, since the median reading age of 15- to 16-year-old deaf children was found to be equivalent to a hearing nine-year-old (Conrad, 1979). The second school did not have systematic standardized evaluation; a grade of B or above on language arts was used as the screening criterion. All subjects were finally selected based on the pre-test word review with the cut-off point at 80%.

Test Instruments and Procedures

1. Metamemory Interview.

Four subtests -- a) story list, b) study plan, c) retrieval event, and d) opposites-arbitrary -- were selected from the Kreutzer et al. (1975) interview. The wording of the retrieval event was slightly modified. Changes were made to story list, study plan, and opposites-arbitrary. A scoring criterion was also developed. Before the interview, the subjects were told that they would be asked some questions about memory and that sometimes pictures were used.

2. Spatial Position Versus Temporal Position Test.

The stimuli were three lists of three letters of the alphabet in each, and three lists of three arabic numbers in each. The letters in upper case and numbers were each printed in black, 5.5 cm high, on a 12.8 cm by 7.6 cm white card. The letters were chosen and combined on the basis that the equivalent handshapes in American sign alphabet do not involve

direction of movement in the formational properties, and visually in orthography they are distinct from each other. The numbers were randomly combined to form groups of three. The lists were: G Y W, F S N, K L D, 7 2 4, 9 5 3, and 1 8 6. The letters A E U were used in practice trials; A and E were confounding handshapes. The letters H J R were used in the instruction procedure. In the presentation, three cards were placed face down in a straight row behind a paper screen. When the screen was removed, each card was exposed for one second, one after another, and put back in the original face down position. The temporal order of exposure did not occur from left to right or right to left in all trials. The second one in the sequence never corresponded to the spatial middle position. Altogether there were eight trials, twice for each sequence, with one alphabet list and one number list used twice in the trials. The subjects were asked either a "spatial middle" or "temporal middle" question after each presentation.

One spatial practice trial and two temporal practice trials were given, using the letters A E U, arranging them according to the [right, left, middle], [middle, right, left], and [middle, left, right] sequences. When the subject failed all test reials, explanation was given briefly again, and the first temporal practice trial was administered again. If the subject still failed, the second temporal practice trial was administered again.

3. Word Review.

The pre-test word review served as an index of the semantic knowledge of the subjects. The 36 words which were used again in the free-recall and paired-associate learning tasks were each printed in black on 12.8 cm by 7.5 cm white cards. The subject was shown one card at a time in the beginning of the test session. To make sure the subject had already known the word, he or she was asked to give the sign equivalent. Finger-spelling was accepted

if the subject could give the definition. If a word was not familiar, the explanation was given; if a word had several possible meanings and the non-targeted meaning was given by the subject, the other meaning was also explained.

4. Paired-Associate Learning.

The paired-associate task explored the possible use of elaboration in varying task conditions. The conditions were determined by the degree of prototypicality inherent in the relationship between the two words. Ten word pairs were printed on a white card 28 cm by 21.5 cm in one column. The pairs were made up of five prototypic and five non-prototypic pairs which were in random order. Five of the cues were words on the left hand side, and five were words on the right hand side. Each cue word was printed on a 12.8 cm by 7.6 cm white card and was exposed for one second. Examples were used in the instruction. Three word pairs not included in the test stimuli were printed on a small white card in one column. A sentence and a drawing describing each of two pairs were printed on a small white card. Each of the two example cues were printed on a small white card. A two minute study period was given to the subject. The exposure time of the cue was one second, and the maximum cue-recall interval was approximately three seconds.

5. Free-Recall.

The free-recall task was designed with categorizable items from four categories, which were people, places, fruit, and body parts. The aim was to assess the use of clustering strategy in contrast to seriation strategy, since both strategies were said to be used frequently in free-recall (Mandler, 1969). Contrary to Postman (1972), who regarded both strategies as equally efficient in list learning, it was suggested in this study that clustering would produce better performance. The stimuli were four categories of four items each. Seven lists were

made with one item of each category adjacent to each other, and no two items of the same category were adjacent to each other. The order of the categories within every four items was randomized. The 16 words were printed in one single column in the middle of a 28 cm by 21.5 cm white card. The lists were randomly assigned to the subjects. Three minutes of study time were given and one minute thirty seconds were allowed for immediate recall.

6. Digit Span.

The digit span forward test was taken from the Wechsler Intelligence Scale for Children-Revised (WISC-R) (Wechsler, 1974). The purpose for its use in this research was to give an index of capacity of working memory. The procedure was different in that the interpreter interpreted each spoken digit for the deaf subjects. Therefore the manual code was used in a sequence. Both trials of the scale were used. Two practice trials each with two numbers (5, 4, 3, 1) were given.

7. Color Sequence Matching.

This task was interpolated between tests as well as an informal enacted context for behavioral observation of sequential or nonsequential strategies. Five colors -- red, blue, green, yellow, and purple -- were used to draw a set of circles and a set of triangles on small white cards. The five cards with triangles were given to the subject, and the researcher used the other set of circles. A sequence of colors was shown, and each card was put back to the fanshape pack held in the other hand after an approximately exposure of one second. The subject was encouraged to follow the sequence as well as the colors. Two colors were used in the two demonstration trials; four trials of three colors and four trials of four colors were used in between the main tasks.

Hypotheses

1. Memory (Recall & Strategy) and Metamemory

Hypothesis 1.1 -- There is a significant positive correlation between metamemory and recall performance.

Hypothesis 1.2 -- There is a significant positive correlation between metamemory and strategy use.

2. Strategy and Recall

Hypothesis 2.1 -- There is a significant positive correlation between appropriate strategy use and recall performance.

3. Between Memory Tasks

Hypothesis 3.1 -- There is a significant positive correlation between word review and performances on paired-associate learning and free-recall.

Hypothesis 3.2 -- There is a significant positive correlation between digit-span and temporal-order recall.

4. Age (Person Variable) and Metamemory

Hypothesis 4.1 -- There is a significant positive correlation between age and metamemory.

5. Age (Person Variable) and Memory (Recall & Strategy)

Hypothesis 5.1 -- There is a significant positive correlation between age and recall performance.

Hypothesis 5.2 -- There is a significant positive correlation between age and appropriate strategy use.

6. Task Conditions (Intra-Task Variables)

Hypothesis 6.1 -- Spatial-to-temporal confusions are significantly less than temporal-to-spatial confusions in encoding.

Hypothesis 6.2 -- Performance on the prototypic items of paired-associate learning is significantly superior to that on the non-prototypic items.

Results

The general profile of performance was indicated by a negative skewness, except on the digit-span test which showed a positive skewness. Significant positive correlations were found

among three metamemory subtests: between story list and study plan, $r = .461$ ($p < .02$); between story list and retrieval event, $r = .726$ ($p = .001$); and between study plan and retrieval event, $r = .571$ ($p = .002$). Inter-subtest correlation was highest between retrieval event and story list, indicating more internal consistency between these two subtests. A metamemory composite score was obtained by summing the scores of the subtests. The subtest correlations with the composite score ranged from moderate to high: $r = .439$ ($p < .02$) for opposites-arbitrary; $r = .775$ ($p < .001$) for story list; $r = .786$ ($p < .001$) for study plan; and $r = .891$ ($p < .001$) for retrieval event. The best indicator of metamemory seemed to be retrieval event followed by study plan and then story list.

Hypothesis 1. Memory and Metamemory

Hypothesis 1.1, which posited that a positive correlation exists between metamemory and memory performance, was not totally supported. Only word review was significantly correlated with three of the metamemory subtests. The Pearson correlation coefficient between word review and story list was .659 ($p < .001$), between word review and study plan was .447 ($p < .02$), between word review and retrieval event was .520 ($p < .005$), and between word review and the metamemory composite score .619 ($p < .001$).

Two organizational strategies, taxonomic clustering and seriation, were computed. In hypothesis 1.2, it was stated that metamemory would correlate positively and significantly with strategy use. Clustering was found to be significantly correlated with the metamemory composite score ($r = .396$; $p < .03$), and also marginally significantly correlated with opposites-arbitrary ($r = .342$; $p < .051$). Seriation was negatively and significantly correlated with study plan ($r = -.359$; $p = < .05$). However, clustering was not significantly correlated with study plan. In sum, the results offered a weak support of hypothesis 1.2.

Hypothesis 2. Strategy and Recall

Hypothesis 2.1, which predicted that better recall performance was correlated with appropriate strategy use, was supported; clustering was highly correlated with free-recall performance, with $r = .902$ ($p < .001$). The relationship between seriation and free-recall performance was nearly zero ($r = .008$). Also, though not reaching significance level, clustering was correlated with digit span ($r = .320$; $p = .064$).

Hypothesis 3. Between Memory Tasks

Hypothesis 3.1, which predicted word review to be positively correlated with free-recall and paired-associate learning, was partly supported. Word review was found to be correlated with free-recall, as well as clustering, with $r = .477$ ($p < .01$), and $r = .515$ ($p = .005$) respectively, and with seriation ($r = -.406$; $p < .03$). The correlation between word review and prototypic paired-associate condition was marginally significant ($r = .342$; $p = .051$). Thus, the hypothesis of the existence of significant positive correlation between word review and the two word-related memory tests was given some support.

Hypothesis 4. Age and Metamemory

The degree of hearing loss was not correlated with any of the measurements, whereas a developmental trend was observed with metamemory performance, but not with memory performance or strategy use. Hypothesis 4.1, which stated that age-increase correlates positively and significantly with metamemory performance, was supported with some qualification. Age correlated significantly with two subtests, story list ($r = .545$; $p = .003$) and retrieval event ($r = .437$; $p < .02$), and with the composite score ($r = .508$; $p < .006$). The correlation of study plan with age was marginally significant with $r = .339$ ($p < .053$), but age was found to be not significantly correlated with opposites-arbitrary.

In general, the choice of strategies on both retrieval event and study plan indicated that higher-order strategies were selected by at least half of the subjects. Fourteen subjects suggested categorization on study plan; six suggested association. On retrieval event, eleven subjects suggested self-indirect elaboration, while one suggested self-direct elaboration on the first trial. However, over 40% were dependent on external and social retrieval cues.

Hypothesis 5. Age and Memory

Hypothesis 5.1 suggested that age increase correlates positively with memory performance, and hypothesis 5.2 suggested that age correlates with better strategy use. With regard to the relationship between age and memory performance, the analysis showed that correlation between age and word review was significant, with $r = .391$ ($p < .03$). Still, it was weak support because correlations with other memory tests were not significant.

Hypothesis 5.2 with regard to age and strategy use was examined with the use of contingency analysis, since the correlation between age and clustering was not significant. Although clustering has been reported in younger children when familiar material was used, the more reliable age for consistent clustering would be the end of elementary school years, since Ornstein, Naus, and Liberty (1975) reported 13-year-olds rehearsed members of categories together. Therefore, the subjects were divided into two groups -- 13.1 years and above, and 13 years and below. The X^2 of 3.267 failed to reach five percent significance level, but the probability was less that 0.10. The relationship between age and appropriate strategy use was not shown to be a linear function since differences at the lower ages were significant when the subjects were divided into three age groups, and therefore hypothesis 5.2 was only partially supported.

Hypothesis 6. Task Conditions

With regard to intra-task variables, it was proposed in hypothesis 6.1 that spatial-to-temporal confusion would be significantly less than temporal-to-spatial confusion. Paired t-tests were calculated, and the t-value was significant only for the comparison between spatial-to-temporal errors and other-random-errors ($t = -2.32$; $p < .03$, 1 tailed; $df = 23$). Thus, the hypothesis was not supported.

Comparison between mean difference of the two conditions of the paired-associate test yielded a significant result (t-value = 2.63; $p < .01$, 1 tailed; $df = 23$). Thus, hypothesis 6.2 was supported, with the performance on the prototypic condition superior to that on the non-prototypic condition. The non-prototypic condition was also found to be positively correlated with temporal position ($r = .467$; $p < .02$) and digit span ($r > .542$; $p = .003$), both of which had not been predicted.

Discussion and Conclusion

The goal of the study was to provide a better understanding of the interaction of the variables involved in the short-term and long-term memory of deaf students. In the present research, a profile description was attempted in regard to the interactions among metamemory, memory processes (representation and retrieval), strategy, knowledge, capacity, age, and task characteristics.

Encoding

The phenomenon of encoding was investigated in relation to the issues which had long been examined in relation to deafness, that is, the ability and efficiency in processing temporal information, and the bias towards spatial processing. Lake (1981) used the term "bias" instead of the term "production inefficiency" coined by Flavell (1971) in her description of the spatial

perceptual set of deaf children. In the present research, the terms "mediation/production deficiency" and "production inefficiency" of Flavell (1971, 1977) and Flavell and Wellman (1977) provide the reference points in the discussion of the encoding process of the deaf subjects.

First of all, the concepts of presentation and representation had to be distinguished from each other. The presentations of the stimuli in the spatial-position task and the temporal-position task were both executed in sequential order over time. However, the stimuli were also presented within a spatial area, that is, in the form of a row. Thus, the presentations of the stimuli could be "represented" from either one of the two perspectives. How the stimuli were represented was therefore entirely from the encoder's point of view. The research studies of O'Connor and Hermelin (1972) and Hermelin and O'Connor (1973) investigated the preferred representation (or encoding) of the perceptual stimuli in an ambiguous context. Lake's (1981) study provided both an ambiguous context and an unambiguous context to distinguish between bias and efficiency in memory representation. In the present study, the subjects were given the ambiguous context but were also made aware of the ambiguity. They were required to encode both spatial and temporal positions, keep them in retention, wait for the ambiguously-worded question, and produce a delayed recall. Therefore, what was investigated was the preferred code or representation; it was solely an investigation of encoding efficiency with rehearsal as well.

The results for the whole sample indicated that mediation deficiency for temporal processing was not evident. Although spatial position recall was higher, the mean temporal position scores were not significantly different from the mean spatial scores, nor were the two types of errors significantly different from each other. The general results showed some indication of inefficiency in encoding since there were significantly more random than spatial-to-

temporal errors. However, the picture was not so simple. With the contingency analysis with the breakdown into 3 age groups, the preadolescent and adolescent groups performed better on the temporal position recall than on the spatial position recall, whereas the late adolescent-young adult group showed a very depressed performance on temporal position recall and also their performance on the spatial position recall was lowest among the three groups although better than their temporal performance. An informal color sequence matching task also produced similar results, with the majority of the sequence users being from the youngest and adolescent groups. Half of the oldest subjects used a simultaneous strategy. Furthermore, the oldest group had the most temporal-to-spatial confusion errors. All this evidence could be taken to suggest that some subjects of the oldest group had a spatial bias, and their temporal processing could be described as showing a mediation deficiency in addition to the production inefficiency shared by all groups, since two-thirds of them also made random errors.

The adolescent group in general did not show a mediation deficiency in temporal encoding; however, production deficiency for spatial encoding seemed to characterize this group as well as production inefficiency. About one-third of this group made temporal-to-spatial errors, and two-thirds made random errors. Also, nearly 62% of this group showed below average performance on the spatial position recall, while approximately 46% performed below average on the temporal version. The youngest group could be described as the group showing the most temporal bias instead of spatial bias; only 40% of them showed below average performance on temporal-order recall, but 60% showed below average performance on spatial-position recall. The percentage of persons in the group making the three different types of errors remained constant at 40%. Therefore, this group could be described as showing some production inefficiency overall, regardless of codes.

Retrieval

Retrieval performance is differentially affected by task requirements and task conditions. Although a substantial number of studies have been done under the metacognitive paradigm with normal children's retrieval strategies, little has been done with deaf children.

The memory tasks, namely free-recall and paired-associate learning, were designed with different levels of potential semantic and organization structure; the prototypic condition in the latter was the most obvious structure.

1. Free-Recall.

On the free-recall task, a great variability in the use of clustering was evidenced. Free-recall seemed to be more determined by semantic memory or the knowledge base, since the highest correlation was with the word review. Metamemorial knowledge as assessed in the four subtests seemed to play a secondary role, and the effect of metamemory was reflected negatively, with a weak negative relationship between seriation and study plan.

2. Paired-Associate Learning.

The retrieval performance on the prototypic condition was marked by ceiling performance; in fact, the stimulus-pairs were so easy that three test items had zero variance. The prototypic condition correlated with only word review among all the measures, at a .05 level of significance. It seemed that the stimulus cue alone was sufficient to evoke the associated response.

Retrieval on the non-prototypic condition, however, showed some contrasting characteristics to the first condition. Apart from significant mean recall difference, with lower performance on the second condition, this condition appeared to be more strategy-mediated than the prototypic one. The moderately high correlations with both temporal position recall

and digit span implied that the retrieval process was similar; possibly cumulative rehearsal over time was used.

Metamemory-Memory Relationship

Metamemorial knowledge was found to be correlated with long-term semantic memory as assessed in word review in this study. One interesting finding particularly important to the encoding ability of the deaf was a low but significant negative correlation between spatial position recall and retrieval event. The relationship between increase of metamemorial ability and decrease of spatial-coding ability could be best explained as that of relative development in reflective thinking and relative transition from a perceptual bias. The present study found that the majority of the preadolescent and adolescent subjects were slightly more proficient in temporal processing; only the late adolescent-young adult group could be described as spatially biased. It seemed that most subjects were at a transitory stage in which spatial perceptual bias was not extreme and temporal processing could take place under conscious control, which the position encoding task dictated. However, the two kinds of encoding seemed not to have arrived at a stage of balance, in which perfect encoding appropriateness under different perceptual and representational demands was achieved. Whether age increase progressively decreases spatial bias and promotes overall encoding efficiency for subjects who exhibited reflective thinking, or whether decrease in spatial bias is dependent on reflective thinking only, has yet to be investigated.

Metamemory and Knowledge

Semantic knowledge played a major role in metamemory performance and strategy use in the present research, and highlighted a knowledge explanation for development (e.g., Chi and Reese, 1983; Gobbo and Chi, 1986). Researchers such as Glaser (1987) and Siegler and

Richards (1982) also concluded that knowledge of specific content domains or expertise is a crucial dimension of high level of competence. Even in the later work on artificial intelligence, researchers have begun to value the superiority of "knowledge-based strategy" as opposed to "power-based strategy" (Minsky and Papert, 1974). The power-based strategy seeks an increase in computational power, such as information retrieval or search algorithms, whereas the knowledge-based strategy improves ways of expressing and utilizing knowledge. This suggestion fits very well with the correlational pattern between story list and word review, retrieval event and word review, study plan and word review, and clustering and word review for the very reason that "construction" with knowledge was important to performance.

Development

The influence of age was more evident on metamemory rather than on short-term memory tests. The correlation between metamemory and two metamemory subtests -- story list and retrieval event -- ranged from moderate to moderately high. The correlation of age with word review was low-moderate. The evidence suggested that metamemory developed as a function of age, whereas the age trend was not so distinct on semantic knowledge, the reason being that the subject sample was selected based on a cut-off point of 80% on word review; therefore, the knowledge base of the younger subjects was nearly equivalent to that of the older subjects. As for the other short-term memory tests, the more strategy-independent ones would also be age-independent.

Age differences in metamemory were qualitative rather than only quantitative. The scores on an individual metamemory subtest were in fact interpretation of qualitative differences, in terms of whether more consistently complex thinking was present. Also, subtle patterns were only discernible with the contingency analyses which were conducted on the

subtests study plan and opposite-arbitrary, indicating that interaction between person and task variables influenced the extent of age differences that could be observed.

Conclusions and Implications

For the average deaf child, hearing loss often brings about communication problems and experiential deprivation. The theories of Feuerstein (1979, 1980) and Vygotsky (1929, 1978) will help to elucidate the origin of this deprivation. In Feuerstein's (1979, 1980) mediated learning theory, apart from maturational processes, development is through interaction with the environment; this concept is similar to Vygotsky's (1929, 1978) theory. Learning is either through direct exposure or mediated exposure to the environment. In mediated exposure, direct experience is altered through the action of an "experienced, intentioned, and active human being" (Feuerstein and Rand, 1977, p. 110). According to Feuerstein (1979) mediated learning is a prerequisite to the development of effective and independent cognitive functioning. Vygotsky (1929, 1978) regarded all higher mental functions as developing through interaction with others and therefore having a mediated structure. Learning is social input, and it precedes development. Development is the internalization of the social input from adults and more capable peers. When internalization of skills takes place, the skills become transformed qualitatively and can be carried out independently. The difference between the level of functioning under the guidance of others (potential level) and the level of functioning independently (actual level) is described as the zone of proximal development by Vygotsky (1978). "What children can do with the assistance of others might be in some sense even more indicative of their mental development than what they can do alone" (Vygotsky, 1978, p. 85).

The mediated learning experience of deaf children needs to be enforced from the earliest age. This can be enforced through supportive counseling given to the parents when

deafness is first diagnosed and through intervention programs. One mediated learning program is the Instrumental Enrichment Program (IE) of Feuerstein (1979, 1980) which was implemented in the Model Secondary School for the Deaf (Jonas and Martin, 1984) and with a number of severely and profoundly deaf students in Alberta (Pachal, 1986). The initial results seemed to be encouraging, as the IE program seemed to have produced improvement in the problem-solving skills and learning attitude of the deaf students (Jonas and Martin, 1984; Pachal, 1986). Another suggestion is the use of reading as the mediating process. Reading seems to be a viable channel to enable the deaf to share the knowledge base of the hearing world; however, reading has not been taught with a goal to enhance metacognitive thinking in the past. As Gormly and Franzen (1978) suggested, the poor reading performance of the deaf may be reflective of the failure of the educational system to teach the meaning of reading. Erickson (1987) proposed an externally guided thinking approach to reading for the deaf. In this approach, the collaborative adult guides the learning process under the assumption of the zone of proximal development (Vygotsky, 1978). Prerequisite knowledge schemata building, a bimodal (sign and oral languages) interlingual format of instruction, and turn-taking metacognitive monitoring are the main components of the externally guided thinking approach. Another need is the encouragement of the study of sign language as a curriculum, especially by profoundly deaf children of hearing parents, so that the linguistic structures are not picked up in a haphazard fashion. With a stable linguistic code, mediated learning experience will be better facilitated.

More research studies replicating the present research method are <u>not</u> recommended, since it was undertaken only for the purpose of bridging the gap between old memory paradigms used in past memory research of the deaf and recent metacognitive and cognitive

paradigms. However, the interpretive focal points such as whether the problem is due to mediation/production deficiency or production inefficiency of strategies, and whether external or internal mediation is present, are strongly recommended. The present research may have exposed some crucial issues. It is hoped that from here other researchers and educators will continue.

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